

DEVICE AND METHOD FOR ERROR AND SYNC DETECTION

BACKGROUND OF THE INVENTION

The present invention relates to a device and a method for performing an error detection operation and a sync detection operation when formatting digital data.

In downstream transmissions for Internet communications using cable modems or for CATV broadcasting in North America and other regions, a data format that is in compliance with the ITU-T J.83 ANNEX B specification is used. According to this specification, packet data including Reed-Solomon decoded data where 1 byte is comprised of 7 bits is converted to a transport stream data packet where 1 byte is comprised of 8 bits. In this process, it is necessary to perform a sync byte detection operation, an error detection operation, and a transport stream sync byte insertion operation for the 7-bit data packet. The series of operations for converting packet data including Reed-Solomon decoded data where 1 byte is comprised of 7 bits to a transport stream data packet where 1 byte is comprised of 8 bits will hereinafter be referred to as an "MPEG framing process".

The MPEG framing process is shown in detail in ITU-T Recommendation J.83, ANNEX B, Digital multi-program System B, B.4 MPEG-2 transport framing. Particularly, Figure B.3/J.83 shows an actual decoding circuit. The circuit is a syndrome

computation circuit for performing the sync byte detection operation.

The specification of the circuit is such that the circuit receives data that is obtained by converting the 7-bit byte Reed-Solomon decoded data to serial bits, and performs a syndrome computation operation using the serial data so as to perform a parity check operation for error detection and to simultaneously perform a sync byte detection operation according to the result of the parity check operation. Then, after performing the parity check operation and the sync detection operation in a serial process, the output data is converted to 8-bit byte data where 1 byte is comprised of 8 bits, thus providing a transport stream data packet.

Typically, the parity check operation and the sync detection operation are performed by transport stream packets, i.e., by 8 bits \times 188 bytes = 1504 bits, thereby requiring a delay of 1496 bits, at minimum, from the first byte to the last byte in 1 packet.

Accordingly, the decoder circuit shown in Figure B.3/J.83 employs a sequence of converting 7-bit byte data to serial bit data, performing a process using a 1497-stage delay element, and then converting the data to 8-bit byte data. Therefore, performing the entire process requires a parallel-to-serial conversion circuit, an MPEG2 sync detection syndrome computation circuit using the 1497-stage

delay element shown in Figure B.3/J.83, and a serial-to-parallel conversion circuit, whereby the circuit scale is significantly large.

5

SUMMARY OF THE INVENTION

An object of the present invention is to provide an error and sync detection circuit that eliminates the need for the 1497-stage delay element and the serial-to-parallel conversion circuit in the output stage.

In order to accomplish this object, the present invention realizes a sequence of first converting 7-bit byte data to 8-bit byte data in a byte-to-byte conversion, and then performing the parity check operation and the sync detection operation by 8-bit bytes, in view of the fact that the MPEG framing process as a whole is a byte-to-byte conversion of converting 7-bit byte data, after performing various operations on the 7-bit byte data.

Specifically, an error and sync detection device of the present invention includes: a data rearrangement block for receiving 7-bit byte data and converting the 7-bit byte data to 8-bit byte data; a parity check block for receiving the 8-bit byte data, which has been converted by the data rearrangement block, and performing an MPEG sync byte detection operation and a parity-check-based error detection operation using the received byte data; and a data storage block, capable of receiving/outputting 8-bit byte data, for

receiving and storing the 8-bit byte data, which has been converted by the data rearrangement block, and 8-bit intermediate byte data produced during a calculation process for the MPEG sync byte detection operation and the parity-check-based error detection operation performed by the parity check block, whereby MPEG packet data that is a collection of 8-bit byte data including a sync byte is output from the parity check block.

In one embodiment of the error and sync detection device, the data rearrangement block produces: first 8-bit byte data that is obtained by combining preceding byte data with an upper 1 bit of following byte data, with the preceding byte data being 7-bit byte data and the following byte data being also 7-bit byte data that is received following the preceding byte data; second 8-bit byte data that is obtained by combining lower 6 bits of the preceding byte data with upper 2 bits of following byte data; and third to seventh 8-bit byte data that are obtained similarly by combining lower n bits ($n=5, 4, 3, 2, 1$) of the preceding byte data with upper m bits ($m=3, 4, 5, 6, 7$) of the following byte data.

In one embodiment of the error and sync detection device: the parity check block includes a first calculation block and a second calculation block for performing a predetermined syndrome computation including an operation of delaying data by a predetermined number of clocks; the first

calculation block receives the 8-bit byte data that is output from the data rearrangement block, and performs a calculation therewith before the operation of delaying the data by a predetermined number of clocks, so as to output intermediate
5 byte data to the data storage block, the intermediate byte data representing a result of the calculation; and the second calculation block receives the intermediate byte data from the data storage block, and performs the calculation therewith before the operation of delaying the data by a predetermined number of clocks, so as to output 8-bit byte
10 data that has undergone the MPEG sync byte detection operation and the parity-check-based error detection operation.

In one embodiment of the error and sync detection
15 device, where pdatai[7:0] denotes input 8-bit byte data, gxot[7:0] denotes data representing a result of a calculation that is performed using the byte data pdatai[7:0], gxot7d[7:0] denotes 8-bit byte data obtained by delaying the calculation result data gxot[7:0] by 7 clocks according to a
20 predetermined reference clock, gx[7:0] denotes an 8-bit intermediate variable that is used in a process of obtaining the calculation result data gxot[7:0], and "^" denotes an exclusive OR operation between bits,

the first calculation block calculates the respective
25 bits gx[7], gx[6], gx[5], gx[4], gx[3], gx[2], gx[1] and gx[0] of the 8-bit intermediate variable gx[7:0] respectively

by the following expressions:

$gx[0]=gxot7d[0];$

$gx[1]=gxot7d[1];$

$gx[2]=gxot7d[2]^{\wedge}gxot7d[0];$

5 $gx[3]=gxot7d[3]^{\wedge}gxot7d[1]^{\wedge}gxot7d[0];$

$gx[4]=gxot7d[4]^{\wedge}gxot7d[2]^{\wedge}gxot7d[1];$

$gx[5]=gxot7d[5]^{\wedge}gxot7d[3]^{\wedge}gxot7d[2];$

$gx[6]=gxot7d[6]^{\wedge}gxot7d[4]^{\wedge}gxot7d[3];$ and

$gx[7]=gxot7d[7]^{\wedge}gxot7d[5]^{\wedge}gxot7d[4]^{\wedge}gxot7d[0],$ and

the first calculation block calculates the respective bits $gxot[7]$, $gxot[6]$, $gxot[5]$, $gxot[4]$, $gxot[3]$, $gxot[2]$, $gxot[1]$ and $gxot[0]$ of the calculation result data $gxot[7:0]$ respectively by the following expressions using the intermediate variable $gx[7:0]$:

$gxot[7]=gx[7]^{\wedge}pdatai[7];$

$gxot[6]=gx[7]^{\wedge}gx[6]^{\wedge}pdatai[7]^{\wedge}pdatai[6];$

$gxot[5]=gx[7]^{\wedge}gx[6]^{\wedge}gx[5]$

$^{\wedge}pdatai[7]^{\wedge}pdatai[6]^{\wedge}pdatai[5];$

$gxot[4]=gx[7]^{\wedge}gx[6]^{\wedge}gx[5]^{\wedge}gx[4]$

20 $^{\wedge}pdatai[7]^{\wedge}pdatai[6]^{\wedge}pdatai[5]^{\wedge}pdatai[4];$

$gxot[3]=gx[7]^{\wedge}gx[6]^{\wedge}gx[5]^{\wedge}gx[4]^{\wedge}gx[3]$

$^{\wedge}pdatai[7]^{\wedge}pdatai[6]^{\wedge}pdatai[5]$

$^{\wedge}pdatai[4]^{\wedge}pdatai[3];$

$gxot[2]=gx[6]^{\wedge}gx[5]^{\wedge}gx[4]^{\wedge}gx[3]^{\wedge}gx[2]$

25 $^{\wedge}pdatai[6]^{\wedge}pdatai[5]^{\wedge}pdatai[4]$

$^{\wedge}pdatai[3]^{\wedge}pdatai[2];$

$gxot[1]=gx[5]^gx[4]^gx[3]^gx[2]^gx[1]$
 $\quad \quad \quad ^pdatai[5]^pdatai[4]^pdatai[3]$
 $\quad \quad \quad ^pdatai[2]^pdatai[1];$ and
 $gxot[0]=gx[4]^gx[3]^gx[2]^gx[1]^gx[0]$
5 $\quad \quad \quad ^pdatai[4]^pdatai[3]^pdatai[2]$
 $\quad \quad \quad ^pdatai[1]^pdatai[0].$

In one embodiment of the error and sync detection device, where $dobx[7:0]$ denotes input 8-bit byte data, $bxotl[7:0]$ denotes data representing a result of a calculation that is performed using the byte data $dobx[7:0]$, $dobx7d[7:0]$ denotes 8-bit byte data obtained by delaying the input byte data $dobx[7:0]$ by 7 clocks according to a predetermined reference clock, $bx[7:0]$ denotes an 8-bit intermediate variable that is used in a process of obtaining the calculation result data $bxotl[7:0]$, $gxotld[7:0]$ denotes 8-bit byte data obtained by delaying the calculation result data $gxot[7:0]$ from the first calculation block by 1 clock according to the reference clock, and "^" denotes an exclusive OR operation between bits,

20 the second calculation block calculates the respective bits $bx[7]$, $bx[6]$, $bx[5]$, $bx[4]$, $bx[3]$, $bx[2]$, $bx[1]$ and $bx[0]$ of the 8-bit intermediate variable $bx[7:0]$ respectively by the following expressions:

$bx[0]=dobx7d[0];$
 25 $bx[1]=dobx7d[1];$
 $bx[2]=dobx7d[2];$

$bx[3]=dobx7d[3];$
 $bx[4]=dobx7d[4];$
 $bx[5]=dobx7d[5]^dobx[1];$
 $bx[6]=dobx7d[6]^dobx[2];$ and
 $bx[7]=dobx7d[7]^dobx[3]^dobx[1],$

the second calculation block calculates the
 respective bits $bxot1[7]$, $bxot1[6]$, $bxot1[5]$, $bxot1[4]$,
 $bxot1[3]$, $bxot1[2]$, $bxot1[1]$ and $bxot1[0]$ of the calculation
 result data $bxot1[7:0]$ respectively by the following
 expressions:

$bxot1[7]=bx[7]^dobx[0];$
 $bxot1[6]=bx[6]^bx[0]^dobx[7];$
 $bxot1[5]=bx[5]^dobx[7]^dobx[6];$
 $bxot1[4]=bx[4]^bx[0]^dobx[6]^dobx[5];$
 $bxot1[3]=bx[3]^dobx[7]^dobx[5]^dobx[4];$
 $bxot1[2]=bx[2]^dobx[6]^dobx[4]^dobx[3];$
 $bxot1[1]=bx[1]^dobx[5]^dobx[3]^dobx[2];$ and
 $bxot1[0]=bx[0]^dobx[4]^dobx[2]^dobx[1],$ and

the second calculation block calculates 8-bit byte
 data $bxot2[7:0]$, representing a result of a calculation that
 is performed based on the calculation result data $bxot1[7:0]$
 and the calculation result data $gxot[7:0]$ from the first
 calculation block, by the following expression:

$bxot2[7:0]=bxot1[7:0]^gxotld[7:0].$

In one embodiment of the error and sync detection
 device, the data storage block receives the 8-bit byte data

from the data rearrangement block and 8-bit byte data representing the result of the calculation performed by the first calculation block, and outputs the two 8-bit byte data after holding the two 8-bit byte data respectively for
5 predetermined periods of time.

In one embodiment of the error and sync detection device, the data storage block is a RAM.

In another aspect of the present invention, the error and sync detection device is implemented as a method.

Therefore, with the device and method for error and sync detection of the present invention, a series of 7-bit byte input data is first rearranged by the data rearrangement block to 8-bit byte data. The 8-bit byte data is input to and stored in the data storage block, and is also input to the parity check block. Each of the 8-bit byte data that has
15 been input to the data storage block is delayed by a predetermined period of time (e.g., by 1496 clocks) before it is input to the parity check block. The parity check block performs the sync detection operation and the parity check operation by using the 8-bit byte data and those that have
20 been delayed by a predetermined period of time.

Thus, 7-bit byte data is converted in a byte-to-byte conversion to 8-bit byte data, and thereafter the 8-bit byte data is consistently used throughout the sync detection operation and the parity check operation. This eliminates
25 the need for a serial-to-parallel converter to be provided in

the output stage, as in the prior art, thereby reducing the circuit scale.

Moreover, since the process is performed by using 8-bit byte data, a RAM can be used as the data storage block, in which case the byte data stored in the RAM may be output after being delayed by a predetermined period of time. Therefore, the circuit scale can be significantly reduced as compared to cases where a delay element having a large number of stages, e.g., 1000 stages or more, is necessary, as in the prior art.

Furthermore, since the calculation process is performed by 8-bit bytes, the calculation method is suitable for CPU operations, etc. Therefore, the present invention is not limited to any particular hardware configuration, and can even be implemented as software.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram illustrating a general configuration of an error and sync detection device in an embodiment of the present invention.

FIG. 2 is a diagram illustrating a configuration of a data rearrangement block provided in the error and sync detection device.

FIG. 3 is a diagram illustrating a data rearrangement method using the data rearrangement block.

FIG. 4 is a block diagram illustrating a

configuration of a parity check block provided in the error and sync detection device.

FIG. 5 is a diagram illustrating a configuration of a first calculation block provided in the parity check block.

5 FIG. 6 is a diagram illustrating a configuration of a second calculation block provided in the parity check block.

FIG. 7A is a diagram illustrating data being stored in a RAM of a data storage block provided in the error and sync detection device.

FIG. 7B is a diagram illustrating changes over time of data being input to and output from the data storage block.

FIG. 8 is a diagram illustrating an operation timing chart of the data storage block.

15 FIG. 9 is a diagram illustrating a section of a decoder circuit, before a 1947-stage delay, that is proposed in ITU-T recommendation J.83 for an MPEG framing process.

FIG. 10 is a diagram illustrating a calculation process performed by the circuit section.

20 FIG. 11 is a diagram illustrating a section of a decoder circuit, after a 1947-stage delay, that is proposed in ITU-T recommendation J.83 for an MPEG framing process.

FIG. 12 is a diagram illustrating a calculation process performed by the circuit section.

25 FIG. 13 is a diagram illustrating a general configuration of a decoder circuit that is proposed in ITU-T recommendation J.83 for an MPEG framing process.

DETAILED DESCRIPTION OF THE INVENTION

An error and sync detection device in a preferred embodiment of the present invention will now be described with reference to the accompanying drawings.

FIG. 1 is a block diagram illustrating a configuration of an error and sync detection device according to the present embodiment. Referring to FIG. 1, the error and sync detection device includes a data rearrangement block 1, a parity check block 2, and a data storage block (data storage device) 3. The data rearrangement block 1 receives 7-bit byte data and converts the 7-bit byte data to 8-bit byte data. The parity check block 2 performs an MPEG sync byte detection operation and a parity-check-based error detection operation by performing calculations using the 8-bit byte data that are successively input to the parity check block 2. The data storage block 3 stores data which needs to be stored while the parity check block 2 performs the MPEG sync byte detection operation and the parity-check-based error detection operation.

FIG. 2 illustrates an internal configuration of the data rearrangement block 1, and FIG. 3 illustrates a data conversion method of the data rearrangement block 1. FIG. 4 is a block diagram illustrating an internal configuration of the parity check block 2.

The parity check block 2 includes a first calculation

block 10, a second calculation block 11, and a selection circuit 12. The function of the first and second calculation blocks 10 and 11 will be generally described below. The first calculation block 10 receives 8-bit byte data from the data rearrangement block 1, performs a calculation on the received 8-bit byte data, and outputs byte data representing the calculation result to the data storage block 3. The second calculation block 11 receives the 8-bit byte data representing the result of the calculation by the first calculation block 10 from the data storage block 3 after passage of a predetermined time period, performs a calculation on the received 8-bit byte data, and outputs data including an MPEG sync byte. The selection circuit 12 selectively outputs either one of the calculation result data from the second calculation block 11 and the byte data output from the data storage block 3, as 8-bit MPEG2 transport stream data.

The configuration and the operation of the data rearrangement block 1, the parity check block 2 and the data storage block 3 will now be described in detail by following the course of the process.

First, 7-bit byte data is input to the data rearrangement block 1. The 7-bit byte data is shifted by 1 bit at a time to generate 8-bit data. There are eight different byte data generation patterns. FIG. 3 shows a process diagram illustrating a method for converting the

input data. First, the 7-bit data is serialized, from which 8-bit data (A, B, ..., J, ...) is produced by shifting the serial data by 1 bit for every clock. As can be seen from FIG. 3, data of an identical pattern is produced every 8
5 clocks. Specifically, 8-bit byte data starting from "A" and 8-bit byte data starting from "I" are of an identical combination pattern. Similarly, 8-bit byte data starting from "B" and 8-bit byte data starting from "J" are of an identical combination pattern.

FIG. 2 illustrates an internal configuration of the data rearrangement block 1 performing the above-described operation. Referring to FIG. 2, the data rearrangement block 1 includes two registers 1a and 1b and a selector 1c. Each of the registers 1a and 1b stores serialized 7-bit data. The registers 1a and 1b are connected in series with each other.
15 Therefore, when one 7-bit byte ("preceding byte data") is stored in the register 1b, the following 7-bit byte ("following byte data") is stored in the register 1a. The selector 1c has first to seventh input terminals, and sequentially selects the input terminals one at a time. The
20 first input terminal receives a total of 8 bits including all bits of the preceding byte data dataireg2[6:0] and the upper 1 bit of the following byte data dataireg1[6]. The second input terminal receives a total of 8 bits including the lower
25 6 bits of the preceding byte data dataireg2[5:0] and the upper 2 bits of the following byte data dataireg1[6:5]. The

third input terminal receives a total of 8 bits including the lower 5 bits of the preceding byte data dataireg2[4:0] and the upper 3 bits of the following byte data dataireg1[6:4]. The fourth input terminal receives a total of 8 bits including the lower 4 bits of the preceding byte data dataireg2[3:0] and the upper 4 bits of the following byte data dataireg1[6:3]. The fifth input terminal receives a total of 8 bits including the lower 3 bits of the preceding byte data dataireg2[2:0] and the upper 5 bits of the following byte data dataireg1[6:2]. The sixth input terminal receives a total of 8 bits including the lower 2 bits of the preceding byte data dataireg2[1:0] and the upper 6 bits of the following byte data dataireg1[6:1]. The seventh input terminal receives a total of 8 bits including the least significant bit of the preceding byte data dataireg2[0] and all bits of the following byte data dataireg1[6:0].

In this way, 7-bit byte data is rearranged into 8-bit byte data in the data rearrangement block 1, and is output to the parity check block 2.

As illustrated in FIG. 4, the parity check block 2 includes the first calculation block 10, the second calculation block 11 and the selection circuit 12. The first calculation block 10 and the second calculation block 11 perform a calculation equivalent to that performed by a specific decoder circuit shown in ITU-T Recommendation J.83, ANNEX B, Digital multi-program System B, B.4 MPEG-2 transport

framing. The configuration of the specific decoder circuit is shown in FIG. 13. The decoder circuit of the figure is a circuit for computing a syndrome based on the following equation:

5
$$f(x)=[1+x^{1497}b(x)]/g(x)$$

where $g(x)=1+x+x^5+x^6+x^8$, and

$$b(x)=1+x+x^3+x^7.$$

First, the 8-bit byte data from the data rearrangement block 1 is input to the first calculation block 10 and at the same time is input to and stored in the data storage block 3.

When calculating a syndrome based on the equation above, the first and second calculation blocks 10 and 11 perform a parallel process by 8-bit byte data received from the data rearrangement block 1. The first calculation block 10 performs a process equivalent to that performed by a circuit section that is preceding (on the input side of) the 1497-stage delay element in the decoder circuit of FIG. 13, and the second calculation block 11 performs a process equivalent to that performed by a circuit section that is following (on the output side of) the 1497-stage delay element in the decoder circuit of FIG. 13. In order to perform this process, the process of the circuit section (whose circuit diagram is shown in FIG. 9) preceding (on the input side of) the 1497-stage delay element in the decoder circuit of FIG. 13 will be analyzed.

In the circuit section illustrated in FIG. 9, the values at Point 0 to Point 8 change over time as illustrated in FIG. 10. FIG. 10 illustrates changes of the values over 8 clocks according to a predetermined reference clock, where the values at Point 7 to Point 0 are X7 to X0, respectively, at a certain point in time and the circuit section starts receiving serial input data a7, a6, ..., a0 from the point in time. It is assumed that the time passes from time 1 to time 2, time 3, and so on. The result of the calculation process on the serial data is the value at Point 8. The serial process calculations at Point 8 from time 1 to time 8 are performed in the first calculation block 10 in a simultaneous, parallel manner at a certain time, thereby realizing a parallel calculation.

The 8-bit byte data input to the first calculation block 10 is subjected to a byte process by the following expressions. Specifically, where pdatai[7:0] denotes the input 8-bit byte data, gxot[7:0] denotes data representing the result of the calculation that is performed using the byte data pdatai[7:0], gxot7d[7:0] denotes 8-bit byte data obtained by delaying the calculation result data gxot[7:0] by 7 clocks according to a predetermined reference clock, gx[7:0] denotes an 8-bit intermediate variable that is used in the process of obtaining the calculation result data gxot[7:0], and "^" denotes an exclusive OR operation between bits, the respective bits gx[7], gx[6], gx[5], gx[4], gx[3],

gx[2], gx[1] and gx[0] of the 8-bit intermediate variable gx[7:0] are calculated respectively by the following expressions:

$$\begin{aligned}
 gx[0] &= gxot7d[0] & (1-0); \\
 gx[1] &= gxot7d[1] & (1-1); \\
 gx[2] &= gxot7d[2] \wedge gxot7d[0] & (1-2); \\
 gx[3] &= gxot7d[3] \wedge gxot7d[1] \wedge gxot7d[0] & (1-3); \\
 gx[4] &= gxot7d[4] \wedge gxot7d[2] \wedge gxot7d[1] & (1-4); \\
 gx[5] &= gxot7d[5] \wedge gxot7d[3] \wedge gxot7d[2] & (1-5); \\
 gx[6] &= gxot7d[6] \wedge gxot7d[4] \wedge gxot7d[3] & (1-6);
 \end{aligned}$$

and

$$\begin{aligned}
 gx[7] &= gxot7d[7] \wedge gxot7d[5] \wedge gxot7d[4] \\
 &\quad \wedge gxot7d[0] & (1-7),
 \end{aligned}$$

and

the respective bits gxot[7], gxot[6], gxot[5], gxot[4], gxot[3], gxot[2], gxot[1] and gxot[0] of the calculation result data gxot[7:0] are calculated respectively by the following expressions using the intermediate variable gx[7:0]:

$$\begin{aligned}
 gxot[7] &= gx[7] \wedge pdatai[7] & (2-7); \\
 gxot[6] &= gx[7] \wedge gx[6] \wedge pdatai[7] \wedge pdatai[6] & (2-6); \\
 gxot[5] &= gx[7] \wedge gx[6] \wedge gx[5] \\
 &\quad \wedge pdatai[7] \wedge pdatai[6] \wedge pdatai[5] & (2-5); \\
 gxot[4] &= gx[7] \wedge gx[6] \wedge gx[5] \wedge gx[4] \\
 &\quad \wedge pdatai[7] \wedge pdatai[6] \wedge pdatai[5] \\
 &\quad \wedge pdatai[4] & (2-4);
 \end{aligned}$$

$$\begin{aligned} \text{gxot}[3] &= \text{gx}[7] \wedge \text{gx}[6] \wedge \text{gx}[5] \wedge \text{gx}[4] \wedge \text{gx}[3] \\ &\quad \wedge \text{pdatai}[7] \wedge \text{pdatai}[6] \wedge \text{pdatai}[5] \\ &\quad \wedge \text{pdatai}[4] \wedge \text{pdatai}[3] \end{aligned} \quad (2-3);$$

$$\begin{aligned} \text{gxot}[2] &= \text{gx}[6] \wedge \text{gx}[5] \wedge \text{gx}[4] \wedge \text{gx}[3] \wedge \text{gx}[2] \\ &\quad \wedge \text{pdatai}[6] \wedge \text{pdatai}[5] \wedge \text{pdatai}[4] \\ &\quad \wedge \text{pdatai}[3] \wedge \text{pdatai}[2] \end{aligned} \quad (2-2);$$

$$\begin{aligned} \text{gxot}[1] &= \text{gx}[5] \wedge \text{gx}[4] \wedge \text{gx}[3] \wedge \text{gx}[2] \wedge \text{gx}[1] \\ &\quad \wedge \text{pdatai}[5] \wedge \text{pdatai}[4] \wedge \text{pdatai}[3] \\ &\quad \wedge \text{pdatai}[2] \wedge \text{pdatai}[1] \end{aligned} \quad (2-1);$$

and

$$\begin{aligned} \text{gxot}[0] &= \text{gx}[4] \wedge \text{gx}[3] \wedge \text{gx}[2] \wedge \text{gx}[1] \wedge \text{gx}[0] \\ &\quad \wedge \text{pdatai}[4] \wedge \text{pdatai}[3] \wedge \text{pdatai}[2] \\ &\quad \wedge \text{pdatai}[1] \wedge \text{pdatai}[0] \end{aligned} \quad (2-0).$$

FIG. 5 illustrates an internal configuration of the first calculation block 10. An exclusive OR circuit (hereinafter referred to as an "XOR circuit") 10a in FIG. 5 calculates Expression (2-7), an XOR circuit 10b calculates Expression (2-6), an XOR circuit 10c calculates Expression (2-5), an XOR circuit 10d calculates Expression (2-4), an XOR circuit 10e calculates Expression (2-3), an XOR circuit 10f calculates Expression (2-2), an XOR circuit 10g calculates Expression (2-1), and an XOR circuit 10h calculates Expression (2-0). Moreover, an XOR circuit 10i calculates Expression (1-7), an XOR circuit 10j calculates Expression (1-6), an XOR circuit 10k calculates Expression (1-5), an XOR circuit 10l calculates Expression (1-4), an XOR circuit 10m

calculates Expression (1-3), an XOR circuit 10n calculates Expression (1-2), an XOR circuit 10o calculates Expression (1-1), and an XOR circuit 10p calculates Expression (1-0). A delay circuit 10q delays the calculation result data gxot[7] by 7 clocks, a delay circuit 10r delays the calculation result data gxot[6] by 7 clocks, a delay circuit 10s delays the calculation result data gxot[5] by 7 clocks, a delay circuit 10t delays the calculation result data gxot[4] by 7 clocks, a delay circuit 10u delays the calculation result data gxot[3] by 7 clocks, a delay circuit 10v delays the calculation result data gxot[2] by 7 clocks, a delay circuit 10w delays the calculation result data gxot[1] by 7 clocks, and a delay circuit 10x delays the calculation result data gxot[0] by 7 clocks.

The values at Point 8 from time 1 to time 8 in FIG. 10 coincide with bit 7 to bit 0, respectively, in the first calculation block 10.

The 8-bit byte data that has been processed in the first calculation block 10 is passed to the data storage block 3 and delayed by 1496 clocks, after which it is passed to the second calculation block 11.

Next, the process performed by the second calculation block 11 will be described. As described above, the second calculation block 11 performs a process equivalent to that performed by a circuit section that is following (on the output side of) the 1497-stage delay element in the decoder

circuit of FIG. 13. FIG. 11 illustrates the circuit section that is following (on the output side of) the 1497-stage delay element in the decoder circuit of FIG. 13. The process performed by the circuit section of FIG. 11 will now be
5 analyzed. FIG. 12 illustrates changes over time of the values at Point 0 to Point 9 shown in FIG. 11. FIG. 12 illustrates changes of the values over 8 clocks according to a predetermined reference clock, where the values at Point 7 to Point 0 are X7 to X0, respectively, at a certain point in time and the circuit section starts receiving serial input data a7, a6, ..., a0 from the point in time. It is assumed that the time passes from time 1 to time 2, time 3, and so on. The result of the calculation process on the serial data is the value at Point 8. The serial process calculations at
15 Point 8 from time 1 to time 8 are performed in the second calculation block 11 in a simultaneous, parallel manner at a certain time, thereby realizing a parallel calculation. The calculation at Point 9 is performed in a serial process from time 1 to time 8 by using data that is obtained by delaying
20 the output result data from the first calculation block 10 and the calculation result data at Point 8. The serial process calculations at Point 8 and Point 9 from time 1 to time 8 are performed in the second calculation block 11 in a simultaneous, parallel manner at a certain time, thereby
25 realizing a parallel calculation.

The 8-bit byte data input to the second calculation

block 11 is subjected to a byte process by the following expressions. Specifically, where $\text{dobx}[7:0]$ denotes the input 8-bit byte data, $\text{bxotl}[7:0]$ denotes data representing the result of the calculation that is performed using the byte data $\text{dobx}[7:0]$, $\text{dobx7d}[7:0]$ denotes 8-bit byte data obtained by delaying the input byte data $\text{dobx}[7:0]$ by 7 clocks according to a predetermined reference clock, $\text{bx}[7:0]$ denotes an 8-bit intermediate variable that is used in the process of obtaining the calculation result data $\text{bxotl}[7:0]$, $\text{gxotld}[7:0]$ denotes 8-bit byte data obtained by delaying the calculation result data $\text{gxot}[7:0]$ from the first calculation block 10 by 1 clock according to the reference clock, and "^" denotes an exclusive OR operation between bits, the respective bits $\text{bx}[7]$, $\text{bx}[6]$, $\text{bx}[5]$, $\text{bx}[4]$, $\text{bx}[3]$, $\text{bx}[2]$, $\text{bx}[1]$ and $\text{bx}[0]$ of the 8-bit intermediate variable $\text{bx}[7:0]$ are calculated respectively by the following expressions:

$$\text{bx}[0] = \text{dobx7d}[0] \quad (3-0);$$

$$\text{bx}[1] = \text{dobx7d}[1] \quad (3-1);$$

$$\text{bx}[2] = \text{dobx7d}[2] \quad (3-2);$$

$$\text{bx}[3] = \text{dobx7d}[3] \quad (3-3);$$

$$\text{bx}[4] = \text{dobx7d}[4] \quad (3-4);$$

$$\text{bx}[5] = \text{dobx7d}[5] \wedge \text{dobx}[1] \quad (3-5);$$

$$\text{bx}[6] = \text{dobx7d}[6] \wedge \text{dobx}[2] \quad (3-6);$$

and

$$\text{bx}[7] = \text{dobx7d}[7] \wedge \text{dobx}[3] \wedge \text{dobx}[1] \quad (3-7),$$

and

the respective bits $bxot1[7]$, $bxot1[6]$, $bxot1[5]$, $bxot1[4]$, $bxot1[3]$, $bxot1[2]$, $bxot1[1]$ and $bxot1[0]$ of the calculation result data $bxot1[7:0]$ are calculated respectively by the following expressions using the intermediate variable $bx[7:0]$ and the 8-bit byte input data $dobx[7:0]$:

$$\begin{aligned} bxot1[7] &= bx[7] \wedge dobx[0] & (4-7); \\ bxot1[6] &= bx[6] \wedge bx[0] \wedge dobx[7] & (4-6); \\ bxot1[5] &= bx[5] \wedge dobx[7] \wedge dobx[6] & (4-5); \\ bxot1[4] &= bx[4] \wedge bx[0] \wedge dobx[6] \wedge dobx[5] & (4-4); \\ bxot1[3] &= bx[3] \wedge dobx[7] \wedge dobx[5] \wedge dobx[4] & (4-3); \\ bxot1[2] &= bx[2] \wedge dobx[6] \wedge dobx[4] \wedge dobx[3] & (4-2); \\ bxot1[1] &= bx[1] \wedge dobx[5] \wedge dobx[3] \wedge dobx[2] & (4-1); \end{aligned}$$

and

$$bxot1[0] = bx[0] \wedge dobx[4] \wedge dobx[2] \wedge dobx[1] \quad (4-0).$$

Moreover, $bxot2[7:0]$ is calculated by the following expression using $bxot1[7:0]$ and $gxot1d[7:0]$:

$$bxot2[7:0] = bxot1[7:0] \wedge gxot1d[7:0] \quad (5).$$

FIG. 6 illustrates an internal configuration of the second calculation block 11 for performing the calculation as described above. In FIG. 6, an XOR circuit 11a calculates Expression (3-7), an XOR circuit 11b calculates Expression (3-6), an XOR circuit 11c calculates Expression (3-5), an XOR circuit 11d calculates Expression (4-7), an XOR circuit 11e calculates Expression (4-6), an XOR circuit 11f calculates Expression (4-5), an XOR circuit 11g calculates Expression (4-4), an XOR circuit 11h calculates Expression (4-3), an XOR

circuit 11i calculates Expression (4-2), an XOR circuit 11j calculates Expression (4-1), and an XOR circuit 11k calculates Expression (4-0). Moreover, an XOR circuit 11l calculates Expression (5). In addition, a delay circuit 11m
5 delays the input 8-bit byte data dobx[7:0] by 7 clocks, and a delay circuit 11n delays the calculation result data gxot[7:0] from the first calculation block 10 by 1 clock.

The values at Point 8 from time 1 to time 8 in FIG. 12 coincide with bit 7 to bit 0, respectively, of the output result data from the second calculation block 11.

The parity check block 2 of the present embodiment performs parity check by performing calculations on byte data in the first calculation block 10 and the second calculation block 11, and the parity check block 2 outputs '47hex' if no error is detected during the transmission of every 188 bytes of 8-bit byte data, or does not output '47hex' if any error is detected. As a result, a parity check operation can be performed through a sync byte detection operation by detecting '47hex'.

20 The selection circuit 12 in the parity check block 2 receives 8-bit byte data that is input thereto from the data storage block 3 and data that represents the parity check result from the second calculation block 11. Then, if the output result data from the second calculation block 11 is
25 '47hex', which indicates a sync byte at the beginning of a transport stream packet, the selection circuit 12 selectively

outputs the '47hex' data. Otherwise, the selection circuit 12 selectively outputs the normal 8-bit byte data that is input thereto from the data storage block 3.

Next, the configuration and the operation of the data storage block 3 will be described. In the present embodiment, the data storage block 3 is a 1496-word, 16-bit, 2-port RAM, and is used for delaying input signals and calculation data by 1496 clocks.

FIG. 7A illustrates a configuration of the data storage block 3, FIG. 7B illustrates changes over time of the data in the data storage block 3, and FIG. 8 illustrates an input/output timing chart. The data storage block (RAM) 3 receives data $di[15:0]$ (16-bit byte) as illustrated in FIG. 7A. The input data $di[15:0]$ is obtained through a bit connecting operation with the output data $pdatai[7:0]$ (8-bit byte) from the data rearrangement block 1 being the lower bits and the output data $gxot[7:0]$ (8-bit byte) from the first calculation block 10 in the parity check block 2 being the upper bits. The RAM 3 also receives a read enable signal nre , a write enable signal nwe , a read address $addrb[10:0]$ and a write address $addra[10:0]$. As can be seen from FIG. 7B, the write address $addra[10:0]$ is obtained by delaying the read address $addrb[10:0]$ by 1 clock, so that a read operation performed on one address is immediately followed by a write operation on the same address. The read enable signal nre and the write enable signal nwe are always at low (low-

active) during an asynchronous period, and are transitioned to low only when correct data is received, i.e., once for every 8 clocks, during a synchronous period. The input data di[15:0] received by the RAM 3 is output as output data do[15:0] after it is delayed by 1496 clocks from when it is input to the RAM 3. The output data do[15:0] is taken in by the parity check block 2 as data doq[15:0] that is obtained by delaying (latching) the output data do[15:0] by 1 clock, and data of the upper 8 bits of the output data do[15:0], i.e., the output data gxot[7:0] from the first calculation block 10, is subjected to the calculation by the second calculation block 11.

As described above, according to the present embodiment, 7-bit byte data is converted to 8-bit byte data by the data rearrangement block 1, and is input to the parity check block 2 and the data storage block 3. In this way, in the parity check block 2, a sync detection operation can be performed by performing calculations by 8-bit bytes while a parity check operation can be performed by performing calculations by 8-bit bytes. Moreover, the data storage block 3 can also handle data by 8-bit bytes. Thus, data can be handled consistently by 8-bit bytes throughout the process starting from the data calculation operation to the transport stream output operation.

The method for computing by 8-bit bytes according to the present invention can be implemented as software with a

CPU being used as hardware. Thus, the method can be implemented in the form of an error and sync detection method that, as software, enables 8-bit byte processes.